# Factorability and the nuclear three-body problem

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# summary

Two utterly completely different methods to solve the bound state three-body problem have been discussed, used and compared in this thesis, for various types of two-body interaction.

On the one hand we considered variational methods. The central problem in the variational approach is the construction of suitable trial functions. In chapter 3 we discuss various ways to obtain high quality approximative wave functions. Chapter 4 is devoted to the application of these methods to various three-boson systems. The assumption of factorability of the trial functions with respect to the internal coordinates $r_1$, $r_2$ and $r_3$ is shown to lead to a considerable simplification of the problem. The variational principle is exploited to derive a set of coupled integro-differential equations in one variable, which may be solved by iteration. The main attention is given to the discussion and solution of the equivalent two-body equations thus obtained. In addition the Austern-Iano method and the straightforward variational method have been considered. In order to investigate to what extent the limitation on the trial functions to be of the product type is restrictive for the quality of the results in one case a trial function of the "double product type" was taken. We conclude the product form to be an excellent approximation.

On the other hand we looked at what we referred to as Mitra-Faddeev, or exact methods, which are of special use if non-local separable two-body interactions occur. If the two-body potentials are non-separable their separable approximations or expansions (suitably truncated) are used to obtain a set of coupled integral equations in one momentum variable for the three-body case. Thus we avoid the two-dimensionality of the integral equations which would arise from local potentials (after angular momentum reduction). Because of the fact that separable interactions play such an important part in this investigation chapter 2 gives a rather detailed discussion of this type of interactions. In addition separable expansions for some local potentials are derived.

In chapter 5 we present exact three-body solutions for the case of rank one separable potentials. Working in coordi-

nate space we carry out straightforward variational calculations for various separable potential shapes as well. A comparison between the two methods is made.

Chapter 6 gives Mitra-Faddeev solutions for the case of local potentials. These local potentials are written as series of separable terms which are suitably truncated. Solutions are presented for potentials which were treated variationally in chapter 4. We are able to estimate the contribution of the higher partial wave parts of the potential to the binding energy to be of the order of a half per cent (for the simple potential considered). A local Bargmann potential, and a separable potential which give the same on-shell T-matrix, and the same two-body binding energy, are shown to give different three-body energies. If the potentials are fitted to the low-energy nucleon-nucleon data, this difference is roughly 1.5 MeV for the triton. This effect should be attributed solely to the different off-shell extensions of the corresponding T-matrices. Therefore it is important to measure experimentally this off-shell behaviour of the nucleon-nucleon T-matrix.